

A Biodiesel Primer:
*Market & Public Policy Developments,
Quality, Standards & Handling*

Prepared by

Methanol Institute



and

International Fuel Quality Center



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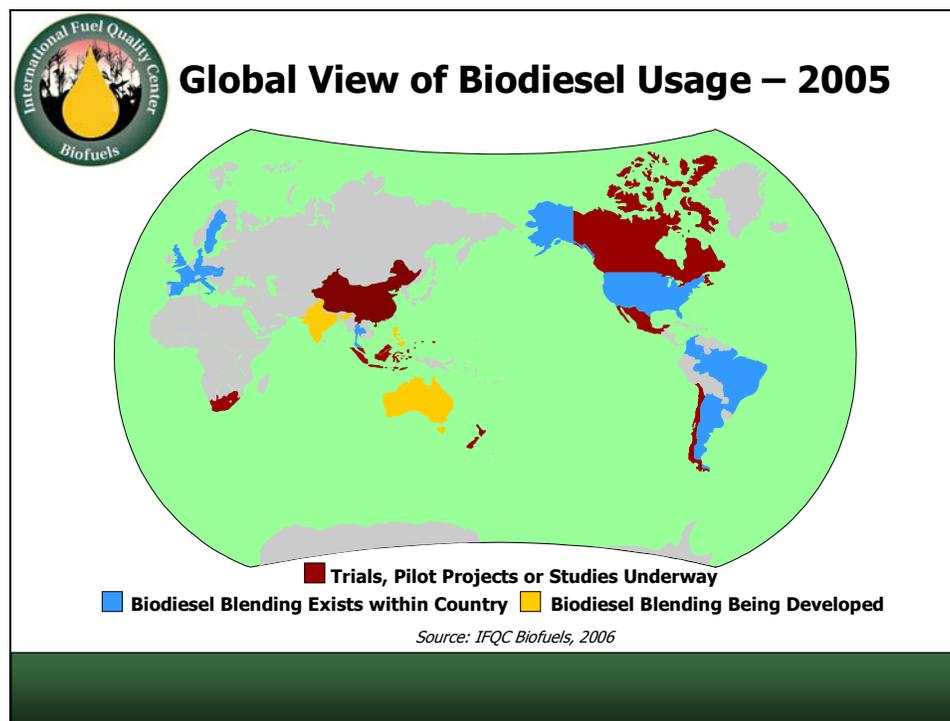
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A. Introduction

When it comes to biodiesel, we are living in exciting times! Never before has the production and use of biodiesel captivated the interest of such a diverse range of groups, including governments around the world; biodiesel producers; auto and engine manufacturers; methanol producers; petroleum refiners; and the end users themselves to name but a few. The enthusiasm and interest in producing and using biodiesel is not limited to the United States; in fact, many countries around the world have developed or are in the process of developing biodiesel programs. Notably, many European countries have been producing and using biodiesel since the early 1990s. The figure below shows countries that are currently using biodiesel:

Figure 1. Worldwide Use of Biodiesel, 2005



There are many reasons, or “drivers,” behind the worldwide enthusiasm for biodiesel fuel because it viewed as:

- A mechanism for reducing dependence on imported oil and extend diesel fuel supplies. This is a major issue for many countries that are “net importers” of crude oil and/or fuel supplies.
- A more environmentally friendly alternative to petrodiesel.
- An alternative to reduce greenhouse gas (GHG) emissions such as CO₂, as well as carbon monoxide (CO), particulate matter (PM) and hydrocarbon (HC) emissions. For example, this is a major driver for the countries of Europe, which are subject to the Kyoto Protocol and thus required to reduce GHG emissions.
- Able to be used in existing diesel engines with proper care and attention.
- Compatible with the existing fuel distribution infrastructure.

- Able to help stimulate agricultural markets and reduce poverty in rural areas by providing jobs for the poor. In fact, this is the primary reason Brazil has opted to develop and implement a national biodiesel program – to help develop the agricultural sector in the north of Brazil and provide jobs for millions of landless poor.

The Methanol Institute and the IFQC Biofuels Center have put together this brief paper to provide the reader with a better understanding of what biodiesel is and how it is produced; the role that methanol plays in the production of biodiesel; public policy initiatives that have been undertaken around the world to promote biodiesel production and use; the importance of assuring quality in biodiesel; warranty issues for diesel engines and vehicles; and, the safe handling of biodiesel and methanol.

B. What Is Biodiesel?

Biodiesel is a clean-burning diesel replacement fuel that can be used in compression-ignition (CI) engines, and which is manufactured from the following renewable, non-petroleum-based sources:

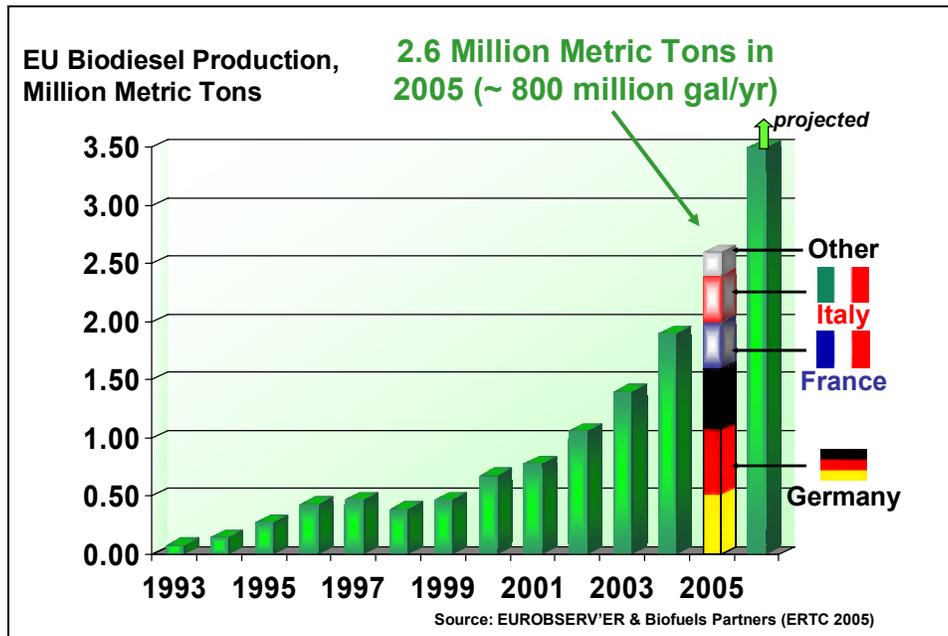
- Virgin vegetable oils such as soy, mustard, canola, rapeseed and palm oils;
- Animal fats such as poultry offal, tallow, and fish oils; and
- Used cooking oils and trap grease from restaurants.

Biodiesel is produced in pure form (100% biodiesel or B100), but is usually blended with petrodiesel at low levels, between 2% (B2) to 20% (B20) in the U.S., but at higher levels in other parts of the world, particularly in Europe, where higher-level blends up to B100 are used. Blends of biodiesel higher than B5 require special handling and fuel management as well as vehicle equipment modifications such as the use of heaters and changing seals/gaskets that come in contact with fuel, according to the National Renewable Energy Laboratory (NREL). The level of care needed depends on the engine and vehicle manufacturer.

Experiments with biodiesel actually date back to the 1850s, even before the CI engine was invented by Rudolf Diesel. Diesel's first engine was powered by peanut oil, and he stated in a 1912 speech that, "the use of vegetable oils for engine fuels may seem insignificant today, but such oils may become, in the course of time, as important as petroleum and the coal-tar products of the present time." Diesel engine manufacturers altered their engines in the 1920s to accommodate the lower thickness, or viscosity, of petroleum-based diesel as compared with vegetable oils and that, combined with petrodiesel's lower cost, effectively ended (at least temporarily) the concept of using renewable vegetable oils for diesel engines.

Though farmers around the world continued to use vegetable oils to power their equipment and machinery, biodiesel's real "revival" began in the 1990s in Europe as commercial plants opened in France, Germany, the Czech Republic, Sweden and Austria. European countries today, particularly Germany, remain the largest producers and users of biodiesel, as the following graph shows:

Figure 2. EU Biodiesel Production, 1993-2005



Source: Jay Ross, Axens North America, "Axens' ESTERFIP-H Solid-Catalyst Biodiesel Technology", March 2006 citing EUROBSERV'ER, 2005 figures.

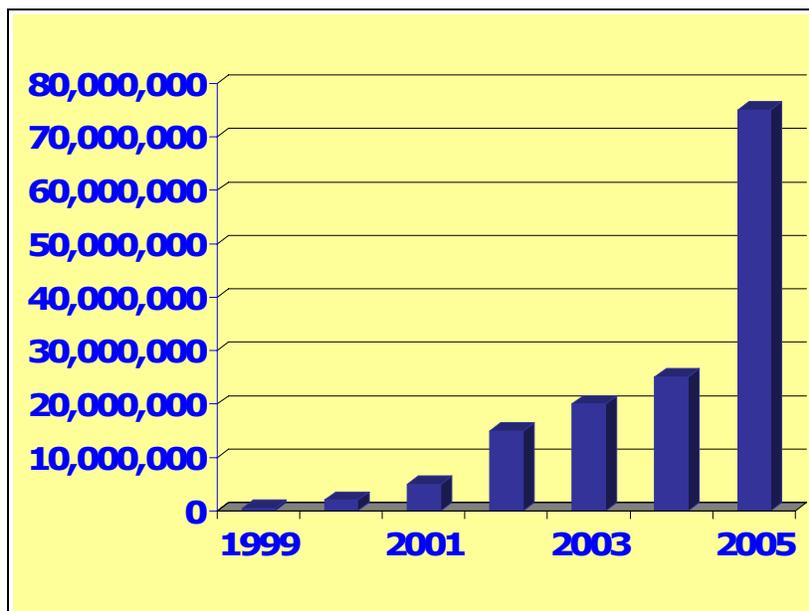
While biodiesel production in the EU commenced with small-scale facilities producing less than 10,000 metric tons per annum (mtpa), the expansion in the market and the involvement of multinational organizations (some with backward integration into oilseed crushing) has resulted in plant size increasing significantly, first through 100,000 mtpa and now to 250,000 mtpa and beyond.

Biodiesel in the EU is largely derived from rapeseed with an 85% market share quoted by Fediol (the European Vegetable Oil Producers and Processors Federation). The remaining feedstocks consist of palm, soybean and sunflower oils together with a limited quantity of waste cooking oils and tallow. This is as a result of the current EN14214 biodiesel specification (discussed in more detail below), which effectively limits the amount of soybean, palm and sunflower oil feedstocks that can be utilized as a blend with rapeseed oil due to the amount of unsaturation present in the fatty acids contained in these oils and the resultant Iodine value.

Though rapeseed oil is the current feedstock of choice for the EU biodiesel industry, the resulting competition with the food sector and indeed other traditional applications for the oil, has driven up the price. This, together with the desire of the EU Commission to take a "balanced approach" to biofuel imports expressed in its Biomass Action Plan, is likely to result in a significant increase in the use of alternate feedstocks in coming years. This will be facilitated by the EU seeking to modify EN14214 (as also indicated in the Biomass Action Plan) to allow the incorporation of higher quantities of alternate feedstocks.

In comparison to Europe, the biodiesel market is still in its infancy in the United States. Consider that 800 million gallons of biodiesel was produced in Europe in 2005, much of it in Germany, but production in the U.S. in 2005 was barely 10 percent of this. Nevertheless, a combination of the aforementioned drivers, along with incentives provided at the state and federal level (described in more detail below), have created a boom in production and use of biodiesel in a very short period of time. Note that in 1999, biodiesel production was just 500,000 gallons, while in 2005, 75 million gallons were estimated to have been produced, according to the National Biodiesel Board (NBB).¹ The jump in production from 2004 to 2005 alone is striking at 25 million to 75 million gallons.

Figure 3. U.S. Biodiesel Production, 1999-2005 (in gallons)



Source: National Biodiesel Board.

There are currently 56 production facilities in the U.S. and another 89 that are in the development stages, according to February 2006 estimates from the IFQC Biofuels Center. Many of these facilities produce small quantities of biodiesel (less than 1 million gallons per year). In Europe, there are at least 75 facilities in operation, with a number under construction that are expected to be operational by the end of this year.

C. Federal and State Public Policy Initiatives to Spur the Production and Use of Biodiesel in the United States

Various agencies of the federal government as well as U.S. states have implemented many initiatives that are meant to spur the production and use of biodiesel. At the federal level, the Energy Policy Act of 1992 (EPAct 1992), the biodiesel tax credit enacted in 2004, the U.S. Department of Agriculture's (USDA) Commodity Corporation Credit (CCC) program, and most recently, the Energy Policy Act of 2005 (EPACT 2005) are the most notable federal public policy

¹ See National Biodiesel Board, Production available at http://biodiesel.org/pdf_files/fuelfactsheets/Production.PDF (last visited Feb. 27, 2006).

programs to encourage biodiesel production and use. At least 31 states have also instituted a number of different initiatives as well.

1. EPAAct 1992

There is no question that the EPAAct program, run by the U.S. Department of Energy (DOE) has had a profound effect on the development of the biodiesel market in the U.S.² EPAAct requires government fleet operators to use a certain percentage of alternatively fueled vehicles (AFVs). EPAAct established a goal of replacing 10% of motor fuels with non-petroleum alternatives by 2000 and increasing to 30% by the year 2010. Today, 75% of all federal vehicles purchased are required to have alternative fuel capability to set an example for the private automotive and fuel industries.

Under the Energy Conservation Reauthorization Act of 1998 (which amended Title III of the Energy Policy Act of 1992), vehicle fleets that are required to purchase AFVs (e.g., government fleets) can generate credit toward this requirement by purchasing and using biodiesel in a conventional vehicle. Since there are few cost-effective options for purchasing heavy-duty AFVs, federal and state fleet providers can meet up to 50% of their heavy-duty AFV purchase requirements with biodiesel.

The biodiesel fuel use credit allows fleets to purchase and use 450 gallons of biodiesel in vehicles in excess of 8,500 pounds gross vehicle weight instead of AFVs. Fleets must purchase and use the equivalent of 450 gallons of pure biodiesel in a minimum of a 20% blend to earn one AFV credit. Covered fleets earn 1 vehicle credit for every light-duty vehicle (LDV) AFV they acquire annually beyond their base vehicle acquisition requirements. Credits can be banked or sold. Compliance with the requirements under EPAAct 1992 is the reason why the Defense Department is the largest purchaser of biodiesel in the U.S.

2. The Biodiesel Tax Credit

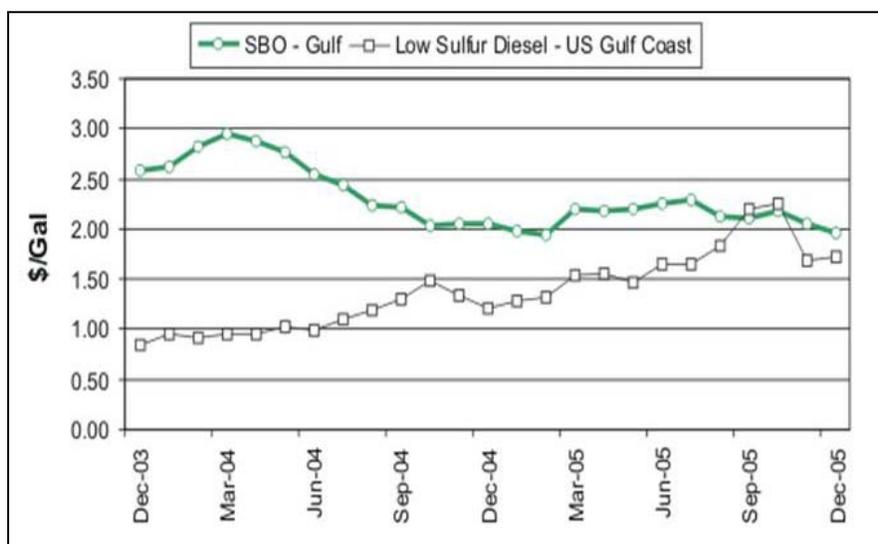
In October 2004, Congress passed a biodiesel tax incentive, structured as a federal excise tax credit, as part of the American Jobs Creation Act (JOBS Act) of 2004. The credit amounts to a penny percentage point of vegetable oil biodiesel blended with petroleum diesel (and one-half penny per cent for recycled oils). Thus, for example, blenders that blend B20 made from soy, canola and other vegetable oils would receive a 20 cent per gallon excise tax credit, while blenders of B5 would receive a 5 cent per gallon tax credit. Biodiesel made from recycled restaurant oils ("yellow grease") would receive half of this credit. For example, B20 blenders would receive a 10 cent per gallon credit; B5 blenders would receive a 2.5 cent per gallon credit.

The tax incentive is taken at the blender level, generally meaning petroleum distributors, and passed on to the consumer. It is designed to lower the cost of biodiesel to consumers in both taxable and tax exempt markets. NBB expects that blenders will be driven to pass most of the savings on to consumers out of sheer competition; however some of the tax incentive may be put toward infrastructure costs. The tax credit under the JOBS Act was scheduled to expire at the end of 2006, but was extended in EPACT 2005 to the end of 2008. There are proposals in Congress pending to extend the tax credit to the end of the decade.

² See U.S. Department of Energy, Energy Efficiency and Renewable Energy Office, *Energy Policy Act (EPAAct)*, <http://www1.eere.energy.gov/vehiclesandfuels/epact/> last updated Feb. 7, 2006

The tax incentive is meant to lower the cost of biodiesel bringing it closer in line to the cost of diesel. According to DOE, this actually began to occur toward the end of 2005 as biodiesel prices for low-level blends were reported to be about the same as for regular diesel, and B20 blends are about 10 cents more per gallon than regular diesel.³ B99/B100 blends (essentially pure biodiesel) were reported to have a cost of about 59 cents per gallon more than regular. The graphic below further illustrates the point. It shows the relationship between the price of soy biodiesel and petrodiesel in the U.S. Gulf region. Note that biodiesel prices were actually cheaper than petrodiesel in the last two months of 2005, due in part to Hurricanes Katrina and Rita, which devastated the region and caused petrodiesel supply shortages for several months.

Figure 4. Estimated Soybean Oil Biodiesel (SBO) Prices v. Low Sulfur Diesel Prices in the US Gulf Coast Region



Source: World Enerav. 2006

3. The USDA's Commodity Credit Corporation Program

Another significant, albeit recent, driver of biodiesel production and consumption is the USDA's Commodity Credit Corporation Bioenergy program.⁴ The program makes monies available to eligible producers of bioenergy fuel, based on the quantity of bioenergy produced during a fiscal year that exceeds the quantity of bioenergy produced during the preceding fiscal year. "Bioenergy fuel" includes ethanol *and* biodiesel.

The payment rates are: (1) Producers of less than 65 million gallons shall be reimbursed 1 feedstock unit for every 2.5 feedstock units of eligible commodity used for increased production; (2) Producers of more than 65 million gallons shall be reimbursed 1 feedstock unit for every 3.5 feedstock units of eligible commodity used for increased production. Approximately \$150 million is available each fiscal year, beginning fiscal year 2003 through fiscal year 2006. In the first

³ See U.S. Department of Energy, *Alternative Fuel Price Report*, last version September 2005.

⁴ See USDA Commodity Credit Corporation, *Bioenergy Program*, available at http://www.fsa.usda.gov/daco/bio_daco.htm#top last visited April 7, 2006.

quarter of 2006, approximately \$4.25 million in payments were paid out to biodiesel producers for approximately 36 million gallons in production.⁵

CCC payments for expansion of biodiesel production in the fiscal years 2004-06 are \$1.45-\$1.47 (2002 dollars) per gallon for soybean oil biodiesel and 89-91 cents per gallon for yellow grease biodiesel. CCC payments effectively reduced the variable cost of additional soybean oil and yellow grease biodiesel to \$1.10 and 53 cents per gallon, respectively, in fiscal year 2004. In 2004, biodiesel producers in the program received more than \$20 million in payments and produced more than 18 million gallons of B100.

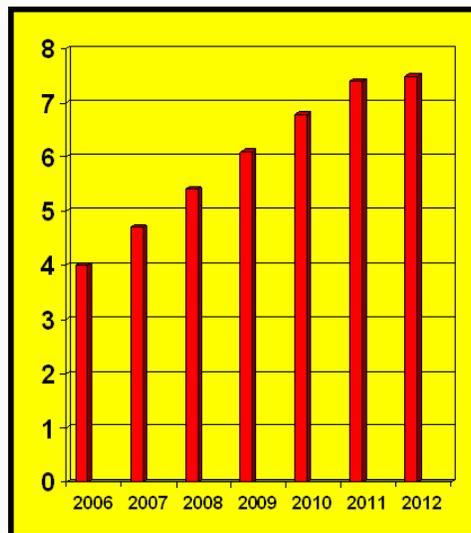
4. EPACT 2005

Congress enacted the EPACT 2005 in August 2005, and included a number of provisions meant to spur the production and use of biodiesel.⁶ In particular, EPACT 2005 provisions include biodiesel as part of the applicable volume in the renewable fuels standard (RFS), though the share allocated to biodiesel and other details are to be determined by EPA through the rulemaking process to implement the RFS. EPACT 2005 also extended the biodiesel tax credit to 2008 from 2006 and included a new tax credit for renewable diesel. These and other important biodiesel-related provisions are summarized below.

i. The Renewable Fuels Standard

The RFS will require a specific amount of renewable fuel, the “applicable volume” to be used in the nationwide gasoline pool. The volume would increase each year, as shown in the graphic below:

Figure 5. US Motor Fuel RFS Targets, in Billion Gallons/Year



Source: Graphic from the IFQC Biofuels Center, citing EPACT 2005.

The Environmental Protection Agency (EPA), which is charged with administering the program, will be required to publish by November 30 of each year, beginning this year, “renewable fuel

⁵ See footnote 4.

⁶ See U.S. House of Representatives, Committee on Energy & Commerce, *Energy Policy Act of 2005*, available at http://energycommerce.house.gov/108/energy_pdfs_2.htm last visited Apr. 7, 2006.

obligations” that will be applicable to refineries, blenders and importers in the contiguous 48 states. There must be no geographic restrictions on where renewable fuel may be used, or per-gallon obligation for the use of renewable fuel. The renewable fuel obligation will be expressed in terms of a volume percentage of gasoline sold or introduced into US commerce and consists of a single applicable percentage that will apply to all categories of refineries, blenders and importers. The renewable fuel obligations will be based on estimates that the Energy Information Administration (EIA) provides to EPA on the volumes of gasoline it expects will be sold or introduced into commerce.

In terms of implementing the RFS for the year 2006, EPA recently released a rulemaking determining that the RFS target for 2006, 4.0 billion gallons of renewable fuel in the gasoline and diesel pool, will be considered to be met, given the current expectations of production of both ethanol (currently over 4.0 billion gallons alone, according to the IFQC Biofuels Center) and biodiesel for this year. If the Agency determines the 2006 target was not met, refiners, blenders and importers will be obligated to make up the shortfall in the year 2007. EPA is expected to release the final rulemaking to implement the RFS by the end of this year.

ii. Credit Trading Program

Refiners, blenders and importers can generate, transfer and use credits for gasoline that contains a greater quantity of renewable fuel than required under the RFS. The credits are valid 12 months from the date of generation. A “renewable fuels deficit” may be carried into the next calendar year if the renewable fuels obligations have not been met and if there are not enough credits generated or available to purchase. However, compliance with the obligation must be achieved in that year and additional credits must be generated or purchased to offset the deficit in the previous year. **EPA must provide for the generation of an “appropriate amount” of biodiesel credits in the rulemaking it issues implementing the RFS program.** There has been discussion about the amount of credit biodiesel will receive, but this has not yet been determined by EPA.

iii. Tax Incentives for Small Agri-Biodiesel Producers, Sec. 1345

The legislation creates a new tax credit for small agri-biodiesel producers with production capacity not in excess of 60 million gallons of 10 cents per gallon for the first 15 million gallons of agri-biodiesel produced.

iv. Renewable Diesel, Sec. 1346

This provision makes clear that renewable diesel is to receive the same tax treatment as biodiesel under the tax code, thus it will receive \$1.00/gallon credit. “Renewable diesel” is defined as diesel fuel derived from biomass using a thermal depolymerization process that meets EPA’s fuels and fuel additive registration process and meets the ASTM standard for diesel, D 975, or for fuel oils, D 396. This provision is effective with respect to fuel sold or used after December 31, 2005. Notably, there is very little renewable diesel produced in the U.S. right now; however, there are a number of companies that are looking to commercialize new technologies to produce renewable diesel using the same, if not more, renewable feedstocks as biodiesel. The main difference is that renewable diesel technologies do not use the transesterification process; rather, many “hydrotreat” the feedstock, reacting it with hydrogen to produce a renewable diesel fuel.

5. Other Incentive Programs Offered at the Federal and State Levels

Aside from these incentives, both federal and state governments offer a broad range of other incentives to spur the production and use of biodiesel. The federal government offers several such programs, but not as many as are offered for ethanol. These programs are summarized in the table below.

Table 1. Other Federal Incentives Meant to Spur Biodiesel Production and Use

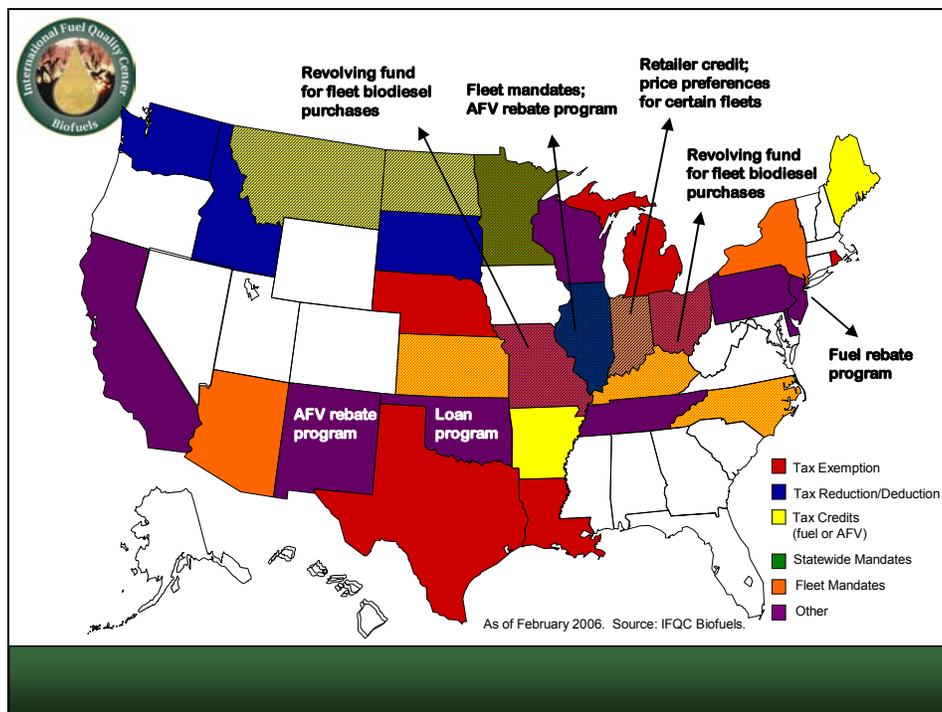
| Federal Agency that Administers/ Oversees | Type of Incentive | Who Receives Incentive | Commonly Known As | Summary |
|---|-------------------|---------------------------------|---|--|
| IRS | Income Tax Credit | Infrastructure Providers | Alternative Fuel Infrastructure Credit | Provides a tax credit in an amount equal to 30% of the cost of any qualified AFV refueling property placed into service in the US – which includes E85 and 20% or more biodiesel mixtures (B20). The credit cannot exceed \$30,000 subject to an allowance for depreciation and \$1,000 in any other case. The tax credit does not apply to residences, and expires after December 31, 2009. |
| Environmental Protection Program (EPA) | Grant Program | School Districts | Clean School Bus Program | Clean School Bus USA reduces operating costs and children's exposure to harmful diesel exhaust by limiting bus idling, implementing pollution reduction technology, improving route logistics, and switching to biodiesel. In fiscal year 2005, the program offered \$7.5 million in cost-shared grants to help school districts upgrade their diesel fleets. The Energy Bill of 2005 utilizes this EPA program to grant up to 50% cost share (depending on the age and emissions of original bus) to replace school buses with ones that operate on alternative fuels or low-sulfur diesel, or up to 100% for retrofit projects. \$55 million are authorized for both 2006 and 2007, and "such sums as necessary" for 2008-2010. |
| USDA | Grant Program | Ag Producers & Small Businesses | Renewable Energy Systems and Energy Efficiency Improvements Grant | In fiscal year 2005, the U.S. Department of Agriculture Office of Rural Development made available \$22.8 million in competitive grant funds and guaranteed loans for the purchase of renewable energy systems and energy improvements for agricultural producers and small rural businesses. The project must occur in a rural area and implement precommercial or commercially available and replicable technology. Research and development does not qualify. The applicant must provide at least 75% of eligible project costs, and grant assistance to a single individual or entity cannot exceed \$750,000. Eligible projects include biofuels, hydrogen, and energy efficiency improvements, as well as solar, geothermal, and wind. |

Source: Compiled by the IFQC Biofuels Center, 2005.

Many states are following the federal government's lead and are offering similar programs and incentives to spur biodiesel production and use. First, the states of Illinois and Minnesota have mandated the use of B2 in all diesel fuel sold in their respective states subject to certain conditions that include sufficient annual production capacity (defined as at least 8 million gallons). The mandate took effect in Minnesota in September 2005; for Illinois, the B2 mandate is expected to become effective in July 2006.

Approximately 31 states provide either user or producer incentives for biodiesel. Several provide both types of incentives and include: Pennsylvania, North Carolina, Illinois, Indiana, Texas, North Dakota and Minnesota. A handful of states, approximately nine at this time, provide incentives to biodiesel producers to build facilities in their states, typically offering tax credits, grants and other financial incentives. Most biodiesel user incentives typically fall into the following categories: tax exemptions, tax reductions/deductions; tax credits for the purchase of AFVs or biodiesel; and, fleet mandates. Two states provide fuel rebate programs, and two provide revolving funds for fleet biodiesel purchases. The figure below summarizes state incentives for biodiesel users.

Figure 6. State Incentives Meant to Spur Biodiesel Use



Source: Compiled by the IFQC Biofuels Center, February 2006.

D. International Biodiesel Developments and Public Policy Initiatives

Other countries have also instituted public policy initiatives to encourage biodiesel production and use, and have done so generally through a combination of fiscal incentives and mandates or voluntary targets, as the chart below shows:

Table 2. Biodiesel Initiatives in Other Countries

| Country | Initiative | Fiscal Incentives | Primary Feedstock |
|-------------|---|--|---|
| Argentina | Legislation pending in the Congress that would require 5% mandatory use of biodiesel and ethanol three years after enactment. | Yes, total tax exemptions for biodiesel from excise duty, sales and income taxes for 15 years | Soy |
| Australia | Biofuels Action Plan: 350 million liters (92 million gallons) target by 2010 | Yes | Looking at all options |
| Brazil | Voluntary B2 program becomes mandatory in 2008; B5 by 2013 | Yes | Soy, mamouna, palm, babassu (nut), tallow, dên-de palm, sunflower |
| Canada | Proposed Renewable Fuels Standard – 5% by 2010 | Yes, excise tax exemptions offered by some provinces | Tallow, yellow grease, fish oil, canola |
| Europe | Biofuels Directive: Voluntary targets require 2% by energy content penetration of biofuels into the gasoline and diesel pools by 2005; 5.75% by 2010. | Yes, a number of members states offer excise tax exemptions or reductions to support biofuels' introduction. | Rapeseed |
| Indonesia | Biofuel consumption to reach 2 vol% total fuels by 2010; 5% by 2025 | Not at this time | Palm oil |
| Malaysia | "National Biofuels Policy"; looking to implement B5 program | Not at this time | Palm oil |
| New Zealand | Voluntary target of 65 million liters (17 million gallons) by 2012 | Not at this time | Tallow |

Source: IFQC Biofuels Center, March 2006.

These initiatives are summarized in more depth as follows:

- Canada:** There is at this time very little biodiesel produced in Canada, at less than 100 million liters. The federal government has stated that before biodiesel can become commercially viable more R&D must be done to make its production cost-effective and address the cold flow issues that biodiesel presents.⁷ However, it is the high cost of production that remains the greatest obstacle to market penetration for biodiesel in blends or as a pure fuel. Still, the interest in biodiesel exists and the government has created a Biodiesel Initiative to overcome barriers to the wide-scale commercialization of biodiesel in the country. Moreover, the country's recently elected Premier has promised to develop a plan that would require a 5% Renewable Fuels Standard that would apply across the gasoline and diesel pools.
- Brazil:** In December 2004, Brazil officially launched its National Biodiesel Program, which introduced biodiesel into the domestic market beginning in 2005. The Program aims to reduce the country's diesel imports while stimulating the domestic agricultural industry that will produce the plant sources needed to make the fuel. In January 2005, Brazilian lawmakers passed LEI No. 11.097, a law that authorizes the voluntary sale of biodiesel fuel for the next three years with a mandatory B2 content starting January

⁷ See Natural Resources Canada, Research, available at <http://oe.nrcan.gc.ca/transportation/fuels/biodiesel/biodiesel.cfm?attr=8> (last updated September 2005); see also Canadian Renewable Fuels Association, Biodiesel in Canada, available at <http://www.greenfuels.org/biodiesel/world.htm#d> (last updated May 2005).

2008; in 2013, B5 will be required. The voluntary program is expected to create 840 million liters/year (221 million gallons) market for biodiesel until the B2 program becomes mandatory in 2008. In 2008, a 1 billion liters/year (264 million gallons) market will be created, according to Agencia Nacional do Petroleo (ANP), which is administering the program. The program is also expected create employment for 65,000 small farm families.

- **Argentina:** Currently, there are approximately 10 plants with a total production capacity of 60,000 tons per year (68 million liters/year or 18 million gallons/year). There is also a tax incentive structured wherein biodiesel producers will receive a 15-year exemption from the country's 15 cents per liter diesel tax, as well as exemptions from the country's gross receipts, income and property taxes, subject to meeting certain requirements. A B5 requirement or mandate for both gasoline and diesel has been discussed in the Congress, but no legislation has yet been enacted.
- **European Union:** The policy framework for the development of a biofuels market in the European Union (EU) is Directive 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport. This Directive sets a voluntary target of 2% biofuel consumption (by energy content) in 2005 rising by 0.75% per year, culminating in a target of 5.75% (also by energy content) in 2010, and includes both ethanol and biodiesel. From a regional perspective the EU as a whole is still far from meeting its 2 vol% (by energy content) consumption target by 2005, even though some of its member states (namely, Germany, France and Italy) are some of the largest biodiesel producers and users in the world.

An emerging theme in the EU is concerned with the cost of maintaining fiscal incentives to support biofuels. This has resulted in certain countries such as Austria, France, Slovenia, Hungary, Germany and UK introducing mandates that require a given percentage of transport fuels to be substituted with biofuels. Sweden and the Netherlands are considering similar schemes as well. A brief summary of member state developments are shown in the table below.

Table 3. Biofuels Developments at the EU Member State Level

| Country | Duty Exemption? | Mandate? | Notes |
|---------|-----------------|--|--|
| Austria | Yes, partial | Yes | 2.5% (by energy content) biofuel usage from October 1, 2005, increasing to 4.3% from October 1, 2007 and to 5.75% (the Directive's objective for 2010) from October 1, 2008. |
| France | Yes, partial | Yes via tax on polluting activities 'TGAP' | The percentage of biofuels that fuel distributors must incorporate into their diesel and gasoline products annually are set at: 1.2% in 2005, 1.75% in 2006, 3.5% in 2007, 5.75% in 2008, 6.25% in 2009, and 7% in 2010. |
| Germany | Yes, total | Admixture | Details yet to be finalized |

| Country | Duty Exemption? | Mandate? | Notes |
|-------------|---------------------------------|--|---|
| | currently; partial from 1/08/06 | obligation to be introduced from 1/1/07 | |
| Italy | Yes, partial | Mandate proposal passed by Senate | The new decree requires that all transport fuels contain 1% (by energy content) biofuels from July 1, 2006 increasing by 1% per annum till 2010. |
| Netherlands | Yes, partial | Mandate to be introduced from 1/1/07 | Fuel suppliers will be required to incorporate 2% biofuels (by energy content) from January 1, 2007. The required biofuels content will then increase annually to meet the EU Commission's target of 5.75% by 2010. |
| Spain | Yes, total | No | The Spanish Renewable Energy Plan sets a target of 5.83% (by energy content) for consumption of biodiesel and bioethanol in the transport sector by 2010. Sales tax breaks of €2.85 billion for bioethanol and biodiesel producers will be provided over the five-year period to support this aim. |
| Sweden | Yes, total | Mandate proposed for introduction on 1/1/09 | The Swedish government is studying a proposal to phase out duty exemptions in favor of a "Green Certificate" system by January 1, 2009. It is recognized that a transitional period may be necessary in which a modified duty exemption system operates in parallel with the new Green Certificate process. |
| UK | Yes, partial | Renewable Transport Fuel Obligation to be introduced from 2008 | The level of obligation will be 2.5 vol% in 2008-2009, 3.75 vol% in 2009-2010 and 5 vol % in 2010-2011. The buy-out price will ultimately replace the duty incentive. |

Note: The above listed countries account for more than 80% of the EU25's potential biodiesel market. Source: IFQC Biofuels Center, 2006.

- **Australia:** The country has established a goal for renewable fuels to contribute at least 350 million liters to the total fuel supply by 2010, which represents some 1 vol% of the combined transport fuel pool. However, the Australian biofuels industry has faced some market barriers including low-consumer confidence and high-commercial risk. Still, oil

companies have indicated that they are prepared to work with the government to ensure that the target is reached. As a result of initiatives to be undertaken by government and industry, the Australian government and its Biofuels Taskforce predict that biodiesel production capacity will increase substantially in the period to 2010. Domestic manufacturing capacity is predicted to exceed the target of 350 million liters of biofuel use by 2010 by a factor of four.

- **India:** In 2003, the country's Planning Commission drafted plans to encourage the widespread planting of *Jatropha curcas* trees as a source of oilseeds for processing into biodiesel. *Jatropha* was chosen specifically as its oil is non-edible and for its tolerance to drought and ability to flourish on wasteland. It therefore does not compete with food crops for arable land. The government plans to extend trials of B5 to commercial use by 2006/7 with B20 being introduced by 2011/12, however, the commission's proposed "biodiesel mission," which was due to launch in April 2005, remains delayed. The Commission is waiting for clarification on several details from the Ministry of Rural Development, which is charged with implementing the mission. For example, the development of the infrastructure to produce sufficient biodiesel to have B5 nationwide will not be without its challenges in that India does not currently have sufficient methanol manufacturing capacity.
- **Thailand:** The Biodiesel Promotion Program was approved by the Thai Cabinet in July 2001 that included the waiver of excise fuel tax as well as an exemption applied for levies for the Oil Fund and the Energy Conservation Fund Contribution. It was planned that B2 will be used in specific biodiesel producing areas in Thailand from mid-2005, with the aim being to mandate the use of this blend in the rest of the country by 2010. PTT, Thailand's national oil company, has further stated that it will introduce B5 into the market in 2007. The Biodiesel Development and Promotion Committee have approved a budget for biodiesel development and promotion for 2005-2012 of Baht 1.3 billion (US\$31.8 million).
- **Malaysia:** Malaysia is the world's largest producer of palm oil – although it is also a net oil and gas exporter – consuming biodiesel domestically would reduce the cost of retail fuel subsidies. In 2003, according to the Malaysian Palm Oil Board (MPOB), Malaysia exported about 92% of its palm oil production of 13.4 million metric tons. Since June 2005, the government has been drafting a National Biofuel Policy. The Policy report is expected to call for the production of biodiesel for use in the transport and industrial sectors to begin in October 2006 with wider-scale use by 2007; as well as the production of biodiesel for export purposes to Europe by October 2006 among other things. There are also ambitions to make the sale of B5 mandatory by 2008, with legislation currently being considered. With the currently announced biodiesel capacity, Malaysia would be able to support B5 in transport fuels till 2010 and have a small quantity of finished biodiesel available for export in addition to the export of palm oil for processing in export markets.

E. Production Process, Specifications & Quality Issues

Biodiesel is generally made when fats and oils are chemically reacted with an alcohol, typically methanol, and a catalyst, typically sodium or potassium hydroxide (i.e., lye), to produce an ester, or biodiesel. The approximate percentage proportions of the reaction are as follows in the table below:

Table 4. Biodiesel Production Input and Output Levels

| Process Input Levels | | Process Output Levels | |
|----------------------|-------------------|-----------------------|-------------------|
| Input | Volume Percentage | Output | Volume Percentage |
| Oil or Fat | 87% | Ester | 86% |
| Alcohol | 12% | Alcohol | 4% |
| Catalyst | 1% | Fertilizer | 1% |
| | | Glycerin | 9% |

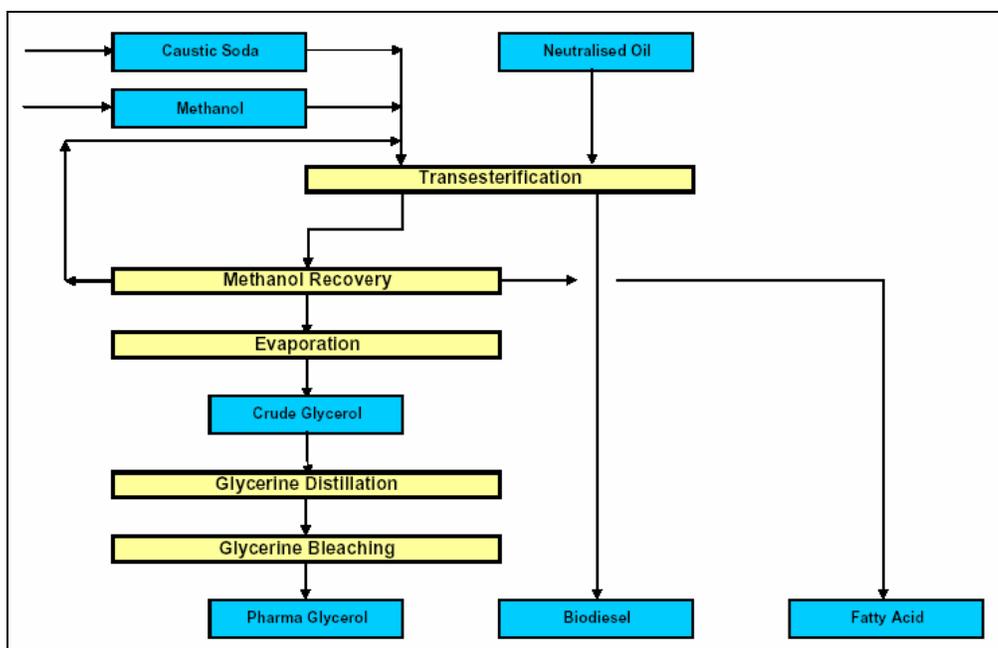
Source: National Biodiesel Board.

This production process is generally known as transesterification, and includes the following processes:

- Base-catalyzed transesterification of the oil with methanol.
- Direct acid-catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to alkyl esters with acid catalysis.

The basic production process is summarized in the figure below.

Figure 7. The Biodiesel Production Process



Source: MAN Ferrostaal.

Excess methanol is used to ensure the process is driven to completion. The basic formula is as follows:

Figure 8. Biodiesel Production Formula

$$100 \text{ pounds of oil} + 20 \text{ pounds of methanol} = 100 \text{ pounds of biodiesel} + 10 \text{ pounds of glycerol} + 10 \text{ pounds of methanol}$$

Source: Methanol Institute.

Since biodiesel is less dense than the glycerol, it floats on top of the glycerol and may be pumped off, or the glycerol can be drained off the bottom. Residual methanol from this reaction is typically removed after the biodiesel and glycerin have been separated, to prevent the reaction from reversing itself. The methanol is cleaned and recycled back to the beginning of the process. Glycerol (used in pharmaceuticals and cosmetics, among other markets) and fertilizer materials are produced as co-products.

Biodiesel IS NOT raw or refined vegetable oils that are unprocessed and should NOT be used as biodiesel fuel. According to the National Renewable Energy Laboratory (NREL), raw or unrefined vegetable oils and greases used in CI engines at levels as low as 10% can cause problems including long-term engine deposits, ring sticking, lube oil gelling, which can reduce the engine's useful life.⁸ These problems generally stem from these oils' greater thickness, or viscosity, compared to that of typical diesel fuels for which the engines were designed. These problems are avoided through the refinement of these oils in the biodiesel production process.

1. Quality Specifications

Specifications for biodiesel have been implemented in several countries around the world, most notably in the U.S., through the American Society of Testing and Materials (ASTM), and in Europe through the European Committee for Standardization (CEN). The relevant committees of these groups that oversee fuel specification development, including standards for biodiesel, are comprised of automobile and engine manufacturers, refining companies, biofuel producers, government entities and other fuel users who agree by consensus on specifications to help ensure good quality fuels for safe and satisfactory operation of vehicles and engines.

In the U.S., the ASTM specification for biodiesel is ASTM D 6751; for the EU, EN 14214. The ASTM specification defines biodiesel as a fuel comprised of mono-alkyl esters of long-chain fatty acids derived from vegetable oils or animal fats. Raw vegetable oils and animal fats that have not been processed do not meet biodiesel specifications. Moreover, the ASTM specification is for biodiesel as a blendstock for blending into petrodiesel, and is not meant to be a specification for B100 as a stand-alone fuel. Note that ASTM standards are not laws in and of themselves; however, many states adopt ASTM standards and transpose them into law. As it pertains to the biodiesel specification, only a few have done so at this time, such as Minnesota.

In Europe, EN 14214 establishes specifications for fatty acid methyl esters for diesel engines. In contrast to ASTM D 6751, B100 that meets this standard could be used unblended in a diesel engine (if the engine has been adapted to operate on B100) or blended with diesel fuel to produce a blend in accordance with EN 590, the European diesel fuel specification. Blends up to 5% of Fatty Acid Methyl Ester (FAME) are allowed in diesel fuel defined by EN 590, which allows for B5 blends to be considered as standard diesel fuel requiring no special markings at the pump. EN 14214, is more restrictive and applies only to mono-alkyl esters made with methanol, fatty acid methyl esters (FAME). The minimum ester content is specified at 96.5%. The addition of components that are not fatty acid methyl esters – other than additives – is not allowed. The table below shows diesel and biodiesel specifications for both the U.S. and EU.

⁸ National Renewable Energy Laboratory, *2006 Biodiesel Handling & Use Guidelines*, DOE/GO-102006-2288 (Mar. 2006) available at <http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/39451.pdf>.

Table 5. Quality Specifications for Diesel and Biodiesel in the U.S. and EU⁹

| Property | UNITED STATES | | | | EUROPEAN UNION | | | |
|--|--|-------------------------|---|-------------|-------------------------------------|---|-----------------------------|----------------------------------|
| | ASTM D975-04c Diesel | | ASTM D6751-03a Biodiesel | | EN 590:2004 Diesel | | EN 14214:2003 Biodiesel | |
| | Spec | Test Method | Spec | Test Method | Spec | Test Method | Spec | Test Method |
| Flash point, min | No 1D 38°C No 2D 52°C | D93 | 130°C | D93 | 55°C | EN 22719 | 120°C | prEN ISO 3679 |
| Water & sediment, max | 0.05% vol | D2709 | 0.05% vol | D2709 | | | | |
| Water, max | | | | | 200 mg/kg | EN ISO 12937 | 500 mg/kg | EN ISO 12937 |
| Total contamination, max | | | | | 24 mg/kg | EN 12662 | 24 mg/kg | EN 12662 |
| Distillation temperature (% vol recovered) | 90%: 1D <288°C 2D 282-338°C | D86 | 90%: <360°C | D1160 | 65%: >250°C 85%: <350°C | EN ISO 3405 | | |
| Kinematic viscosity | 1D 1.3-2.4 mm ² /s 2D 1.9-4.1 mm ² /s | D445 | 1.9-6.0 mm ² /s | D445 | 2.0-4.5 mm ² /s | EN ISO 3104 | 3.5-5.0 mm ² /s | EN ISO 3104 |
| Density | | | | | 820-845 kg/m ³ | EN ISO 3675 EN ISO 12185 | 860-900 kg/m ³ | EN ISO 3675 EN ISO 12185 |
| Ester content | | | | | < 5% FAME | EN 14078 | > 96.5% | EN 14103 |
| Ash, max | 0.01% wt | D482 | | | 0.01% wt | EN ISO 6245 | | |
| Sulfated Ash, max | | | 0.020% wt | D874 | | | 0.02% wt | ISO 3987 |
| Sulfur, max (by weight) | 1D and 2D: S15 15 ppm S500 0.05% S5000 0.5% | D5453 D2622 | Two grades: S15 15 ppm S500 0.05% | D5453 | Two grades: 50 mg/kg 10 mg/kg | EN ISO 14596 EN ISO 8754 EN ISO 24269 | 10 mg/kg | prEN ISO 20846 prEN ISO 20884 |
| Copper strip corrosion | < No 3 | D130 | < No 3 | D130 | class 1 | EN ISO 2160 | class 1 | EN ISO 2160 |
| Cetane number, min | 40 | D613 | 47 | D613 | 51.0 | EN ISO 5165 | 51.0 | EN ISO 5165 |
| Cetane index, min | | | | | 46.0 | EN ISO 4264 | | |
| One of: - cetane index - aromaticity | > 40 < 35% vol | D976 D1319 | | | | | | |
| PAH, max | | | | | 11% wt | IP 391 EN 12916 | | |
| Operability, one of: - cloud point - LTFT/CFPP | Regional requirements | D2500 D4539 D6371 | | | | | | |
| Cloud point | | | report | D2500 | Location & season dependant | EN 23015 | | |
| CFPP | | | | | Location & season dependent | EN 116 | Location & season dependent | EN 116 |
| Carbon residue, max | 1D: 0.15% wt 2D: 0.35% wt | D524 | 0.050% wt | D4530 | 0.30% wt | EN ISO 10370 | 0.30% wt | EN ISO 10370 |
| Acid number, max | | | 0.80 mg KOH/g | D664 | | | 0.50 mg KOH/g | EN 14104 |
| Oxidation stability | | | | | < 25 g/m ³ | EN ISO | > 6.0 hrs | EN 14112 |

⁹ See Hannu Jääskeläinen, *Biodiesel Fuel Standards*, featured on DieselNet and citing ASTM and CEN standards.

| Property | UNITED STATES | | | | EUROPEAN UNION | | | |
|--|----------------------|-------------|--------------------------|-------------|--------------------|-------------|---|----------------------|
| | ASTM D975-04c Diesel | | ASTM D6751-03a Biodiesel | | EN 590:2004 Diesel | | EN 14214:2003 Biodiesel | |
| | Spec | Test Method | Spec | Test Method | Spec | Test Method | Spec | Test Method |
| | | | | | | 12205 | | |
| Iodine value | | | | | | | < 120 | EN 14111 |
| Methanol | | | | | | | < 0.20% wt | EN 14110 |
| Linolenic acid methyl ester | | | | | | | < 12.0% wt | EN 14103 |
| Polyunsaturated methyl esters | | | | | | | < 1% wt | No method specified |
| Monoglycerides, diglycerides & triglycerides | | | | | | | MG <0.8% wt DG <0.2% wt TG <0.2% wt | EN 14105 |
| Group I metals (Na + K) | | | | | | | < 5.0 mg/kg | EN 14108 EN 14109 |
| Group II metals (Ca + Mg) | | | | | | | < 5.0 mg/kg | EN 14538 |
| Free glycerin, max | | | 0.020% wt | D6584 | | | 0.02% wt | EN 14105 EN 14106 |
| Total glycerin, max | | | 0.240% wt | D6584 | | | 0.25% wt | EN 14105 |
| Phosphorous, max | | | 0.001% wt | D4951 | | | 10 mg/kg | EN 14107 |
| Lubricity | < 520 μ m | D6079 | | | < 460 μ m | ISO 12156-1 | | |

Source: DieselNet, citing ASTM and CEN standards.

The table below explains the purpose and importance of the ASTM specifications in D 6751.

Table 6. ASTM Specifications and Their Importance

| Property & Units | Purpose | Importance |
|------------------------|--|---|
| Flash point | Fire safety | B100 flash point is typically higher than diesel to ensure that excess methanol has been removed. |
| Water and sediment | Prevent corrosion and proliferation of organisms | Set at the same level as for conventional diesel fuel. Excess water can lead to corrosion and provides an environment for the proliferation of microorganisms. Oxidation can increase sediment levels; thus, this test can be used with tests for acid number and viscosity to determine whether fuels have oxidized too much during storage. |
| Kinematic viscosity | Satisfactory fuel combustion | Minimum viscosity set at the same level as for conventional diesel. Allows for slightly higher viscosity than for conventional diesel fuel. |
| Sulfated ash | | Prevent injector deposits |
| Sulfur | Protect exhaust catalyst systems | Biodiesel generally contains less than 15ppm sulfur; NREL recommends ASTM D 5453 as the most appropriate test method for accurate results. |
| Copper strip corrosion | Indicates difficulties with bronze and copper vehicle components | Same as for conventional diesel. Generally not an issue for biodiesel. |
| Cetane number | Good engine performance | Conventional diesel must have a minimum cetane of 40; 47 was chosen here because this is the level identified by the US Conference of Weights and Measures as premium diesel and also because 47 is the lowest level found in biodiesel produced and used in the US. |
| Cloud point | Good performance in cold temperatures | A significant issue for the US as biodiesels produced from different feedstocks do perform differently in different geographic and climates in the US. |

| Property & Units | Purpose | Importance |
|--------------------------|--|---|
| Carbon residue | Indicates tendency of deposits to form on the engine | |
| Acid number | Ensuring engine deposits do not form | An indicator of free fatty acids (FFAs); acid numbers higher than 0.80 have been found to cause fuel system deposits and reduced life for fuel pumps and filters. |
| Free glycerin | Biodiesels that exceed these limits can cause storage tank, fuel system, engine fouling, and filter plugging. | |
| Total glycerin | | |
| Phosphorus content | Prevent damage of catalytic converters | Phosphorus that exceeds these limits can damage catalytic converters. Some vegetable oils do contain 10 ppm or higher phosphorus; biodiesel in the US typically has low phosphorus, around 1 ppm. |
| Distillation temperature | Incorporated to ensure that fuels have not been contaminated with high boiling materials such as used motor oil. | |

Source: NREL, *Biodiesel Handling & Use Guidelines*, 2006.

Other countries have adopted biodiesel specifications also and include Canada, Brazil and Australia.

2. Recent Biodiesel Quality Issues

i. Quality Assurance in Europe

Reports of biodiesel not meeting specifications in Europe, or “off-spec” biodiesel, are a rare occurrence. However, past surveys of B100 fuel quality by vehicle equipment manufacturers such as Bosch have highlighted relatively high instances of biodiesel being out of specification on oxidation stability and/or CFPP. As a result of such findings, a group of manufacturers and distributors of biodiesel in Germany and Austria have formed the “Arbeitsgemeinschaft Qualitätsmanagement Biodiesel e. V.” (AGQM) (Working group for Biodiesel Quality Assurance).

Compliance with the mandatory standard and additional voluntary quality criteria and requirements are ensured by an extensive quality management system extending from the raw material to the tank of the biodiesel customer. Of approximately 17,000 filling stations, some 1,700 sell biodiesel and of these, over 1,300 stations have adopted the AGQM quality assurance system under a brand license contract. The owners of these filling stations have pledged to comply with the standards and requirements of the AGQM. This also includes a mutual pledge that only biodiesel based on rapeseed oil methyl ester will be offered for sale at public filling stations. This is due to the fact that several vehicle manufacturers only approve rapeseed methyl ester (RME) for use in their vehicles. The pumps of the participating filling stations are marked with a special symbol showing a yellow drop in a green “Q”.

ii. ASTM B20 and B5 Standards

There is no separate approved specification for biodiesel blends at this time, though there are proposals pending within ASTM for a B20 standard. There is also a proposal to permit 5% biodiesel blends (B5) under the current diesel specification, D 975. The current practice for biodiesel blends is to ensure that the diesel meets D 975, and the biodiesel meets D 6751 prior to blending. B20 cannot meet D 975 because it cannot meet the viscosity and distillation standards, though B5 (and lower blends) can meet D 975. Low-level biodiesel blends that

meet D 975 can generally be used interchangeably with conventional diesel as long as the biodiesel itself meets D 6751 and the cold flow properties of the blend are adequate for the particular geography, climate and time of year the biodiesel is going to be used.

iii. Minnesota B2 Quality Problems

The state of Minnesota was the first in the nation to require diesel fuels sold in the state to be blended with biodiesel at 2 vol%. The state has had numerous quality problems since its B2 program began in September 2005, and has had to grant several waivers of the program as a result. The most recent waiver was granted in January 2006.¹⁰ Some of the biodiesel produced in the state is not meeting the ASTM D 6751 specification, with preliminary testing having showed that a few batches of biodiesel contain high levels of glycerin. At the same time, truckers complained of sputtering, stalled vehicles during cold spells and gummy deposits that are plugging fuel lines. According to the Minnesota Trucking Association (MTA), a recent survey showed that of the 90 fleets responding, 62% experienced fuel filter plugging and of those, 66% experienced repeated plugging on the same truck, reporting a black sludge or wax in their filters.

As a result, the National Biodiesel Board (NBB) and the Minnesota Biodiesel Council (MBC) presented an action plan in January 2006 to the Minnesota Department of Commerce (MDC), the state authority charged with enforcing the B2 program, to increase quality control. The measures proposed include:

- Requiring all biodiesel producers to become accredited under the voluntary BQ-9000 quality assurance certification program established by NBB. (Accreditation under the BQ-9000 program is open to all companies actively producing, distributing or marketing, or planning to produce, distribute or market, biodiesel fuel either in its neat form or for use in blending with a petroleum diesel fuel (or similar fuel). Accreditation is awarded for two years following a successful formal review and audit of the capacity and commitment of the applicant to produce or market biodiesel fuel that meets the ASTM D 6751 specification. The accreditation process is comprehensive and includes a detailed review of the applicant's Quality System documentation, followed by a formal audit of the applicant's conformance to its System.)
- Requiring a certificate of analysis for each batch of biodiesel fuel produced; and
- Requiring stronger enforcement procedures from the MDC, including suspensions and fines for producers that sell off-spec fuel.

The quality issues in Minnesota highlight the absolute importance of ensuring that biodiesel meets specifications. In fact, since the program has been reinstated, the state, truckers, biodiesel blenders and the petroleum industry are finding *no* quality issues with biodiesel.

F. Warranty Issues

The World Wide Fuel Charter (WWFC) is prepared and supported by the Alliance of Automobile Manufacturers (AAM), European Automobile Manufacturers Association (ACEA), Engine Manufacturers Association (EMA) and Japanese Automobile Manufacturers Association

¹⁰ See Tom Webb, *Biodiesel Industry gets Time to Fix Problem*, ST. PAUL PIONEER PRESS, Jan. 12, 2006; Tim Pugmire, *State Suspends Biodiesel Fuel Mandate*, MINNESOTA PUBLIC RADIO, Dec. 23, 2005; *Minnesota: Some Saw Biodiesel Woes Coming*, GRAND FORKS HERALD, Jan. 1, 2006; *Minnesota Temporarily Suspends Biodiesel Rule*, FLEET OWNER, Dec. 27, 2005.

(JAMA).¹¹ The WWFC is a statement by the world's auto industry on the quality of fuels needed to ensure optimal operation of different types of vehicles they manufacture and that are in use around the world. Recommended specifications are provided for four different categories of gasoline and diesel fuels.

The draft WWFC (of August 2005) allows the addition of biodiesel at up to 5% by volume in Fuel Categories 1-3, and thus guarantees vehicles using biodiesel at these blends with the following caveat; for biodiesel, both EN14214 and ASTM D6751, or equivalent standards, should be considered. Where biodiesel is used it is recommended that fueling pumps be marked accordingly.

For Category 4 fuels, the WWFC calls for biodiesel to be none detectable (i.e., at or below detection limit of the test method used, which is specified as EN 14078). This means that automakers do not accept biodiesel in the most advance vehicles and thus will not guarantee warranties. Automakers would reserve the right *not* to repair a vehicle under warranty if the origin of the problem was perceived to be poor or inappropriate fuel quality.

Generally, biodiesel is believed to enhance the lubricity of conventional diesel fuel and reduce exhaust gas PM. At the same time, engine and auto manufacturers have concerns about introducing biodiesel into the marketplace, especially at higher levels, because:

- As has been noted, biodiesel may be less stable than conventional diesel fuel, so precautions are needed to avoid problems linked to the presence of oxidation products in the fuel. Some fuel injection equipment data suggest such problems may be exacerbated when biodiesel is blended with ultra-low sulfur diesel fuels.
- Biodiesel requires special care at low temperatures to avoid an excessive rise in viscosity and loss of fluidity. Additives may be required to alleviate these problems.
- Being hygroscopic, biodiesel fuels require special handling to prevent high water content and the consequent risk of corrosion and microbial growth.
- Deposit formation in the fuel injection system may be higher with biodiesel blends than with conventional diesel fuel, so detergent additive treatments are advised.
- Biodiesel may negatively impact natural and nitrile rubber seals in fuel systems. Also, metals such as brass, bronze, copper, lead and zinc may oxidize from contact with biodiesel, thereby creating sediments. Transitioning from conventional diesel fuel to biodiesel blends may lead to an especially large increase in sediments that may plug fuel filters. Thus, fuel system parts must be specially chosen for their compatibility with biodiesel.
- Neat (100% or B100) biodiesel fuel and high concentration biodiesel blends have demonstrated an increase in NOx exhaust emission levels.
- Biodiesel fuel that comes into contact with the vehicle's shell may be able to dissolve the paint coatings used to protect external surfaces.

¹¹ Alliance of Automobile Manufacturers, et al., World Wide Fuel Charter (proposed revision Aug. 2005).

In view of the high level of interest in this fuel, auto and engine manufacturers will continue to investigate how to achieve appropriate quality for biodiesel-containing fuels in the marketplace.

In Europe, some manufacturers have sanctioned the use of certain vehicles with B100 or B30 fuels, but the majority of vehicles are only approved for use with EN590 diesel, which by definition currently contains a maximum of 5% by volume of biodiesel. Automakers have raised concerns over the suggested increase in the blend limit to 10% by volume due to concerns over compatibility of such a fuel with the existing fleet and the potential for increased emissions. As regards new vehicles, automakers are not opposed in principle given that a B10 standard is established and EN14214 is reconsidered.

In the U.S., the position of most automakers is that biodiesel blends up to 5% (and in some cases up to 20%) is acceptable as long as it meets D 6751. Moreover, the American Trucking Association has also approved B5. Many are concerned about blends higher than 5% because of quality and stability (discussed above) and want a B20 ASTM standard. Of course, manufacturers do warrant their products against defects associated with materials and workmanship and the use of biodiesel in and of itself does not void the warranty – this is prohibited by a federal law known as the Magnuson-Moss Warranty Act. The table below summarizes the position statements and recommendations on biodiesel usage.

Table 7: OEM Positions and Recommendations on Biodiesel Usage

| Manufacturer | Position |
|--|--|
| Engine Manufacturers Association (EMA) | B5 acceptable if it meets D 6751. |
| Caterpillar | Many engines approved for B100; for others only B5 is acceptable. Must meet D 6751. |
| Cummins | All engines approved for B5; must meet D 6751. |
| DaimlerChrysler | B5 acceptable for all vehicles, but must meet D 6751. |
| Detroit Diesel | B20 approved for all engines/vehicles, but must meet DDC specific diesel fuel specification. |
| Ford | B5 acceptable for all vehicles, but must meet both D 6751 and EN 14214. |
| General Motors | B5 acceptable for all vehicles, but must meet D 6751. |
| International Truck and Engine | B20 acceptable for all engines, but must meet D 6751. |
| John Deere | B5 acceptable for all engines, but must meet D 6751. |
| Volkswagen | B5 acceptable for all engines, but must meet fuel quality standards (D 6751 or EN 14214). |
| Fuel Injection Equipment Manufacturer | Position |
| Bosch | B5 acceptable for all vehicles, but must meet EN 14214. |
| Delphi | B5 acceptable for all vehicles, but must meet D 6751. |
| Stanadyne | B20 acceptable for all vehicles, but must meet D 6751. |

Source: IFQC Biofuels Center. See also, NBB, Fact Sheet: Standards & Warranties, available at http://biodiesel.org/resources/fuelfactsheets/standards_and_warranties.shtm.

G. The Safe Handling of Biodiesel and Methanol

Methanol plays a critical role in the production of biodiesel. Methanol, also known as wood alcohol or methyl alcohol, is made primarily from natural gas or coal, and is also produced from renewable resources such as landfill gas and digester gas. Moreover, methanol is an essential chemical building block used to make hundreds of products that touch our daily lives, from plastics and paints, to construction materials and clothing. Strong economic growth has methanol demand increasing at a healthy 4% per year on a global basis. The emergence of

biodiesel in virtually every major region in the world adds tremendous potential to the methanol picture. While starting from a small base of less than 100,000 metric tons in 2005, global methanol demand for biodiesel production could reach as much as 1.5 million metric tons by 2010.

On the supply side, the methanol industry is undergoing fundamental changes through a process of expansion and rationalization. Vast reserves of natural gas have been discovered in many parts of the world, including the Caribbean, South America and the Middle East/Africa. In some of these regions, natural gas is available at a cost of less than \$1.00 per million BTUs. New "mega-methanol" plants with production capacities of 5,000 tons per day (1.7 million tons annually or about 600 million gallons) are being built in countries such as Trinidad and Tobago. The global methanol industry is being rapidly transformed into a dynamic chemical and fuels powerhouse that is seen as a key strategic partner to the also dynamic and burgeoning global biodiesel market.

It is true that biodiesel and methanol are biodegradable, which means that both will dissipate quickly after a spill. Biodiesel also has a high flashpoint and low volatility, so it does not ignite as easily as conventional diesel, increasing the margin of safety in its handling. Biodiesel degrades four times faster than conventional diesel and is not particularly soluble in water. It is nontoxic, so it is generally safe to handle, transport, and store. Methanol is a colorless liquid with a faint alcohol odor that is fully soluble in water and readily biodegradable in both water and soil.

Even though biodiesel and methanol are both biodegradable, extreme care and caution needs to be applied in handling them both, particularly methanol. Many individuals are buying methanol from race tracks and other suppliers to make their own biodiesel at home, but have little to no knowledge about how to handle methanol properly and how to protect themselves and others from toxic exposure to methanol. When properly contained and handled and when personnel are properly trained, methanol can be a safe and effective product for a wide range of applications, including biodiesel production. It is NOT safe to handle biodiesel or methanol without proper training and instruction from someone who is knowledgeable and qualified.

Methanol is a hazardous chemical that is highly flammable and extremely toxic to humans if ingested or if vapors are inhaled. Direct exposure to methanol should be avoided, as methanol can be harmful if swallowed, absorbed through the skin, or inhaled. Ingestion of as little as one to four ounces can cause irreversible injury to the nervous system, blindness or even death. Methanol can cause poisoning, systemic acidosis, optic nerve damage and central nervous system (CNS) effects. Methanol can also degrease the skin, which may cause dermatitis. Symptoms of acute methanol exposure may include headache, weakness, drowsiness, nausea, difficult breathing, drunkenness, eye irritation, blurred vision, loss of consciousness, and possibly death. Patients may improve and then get worse up to 30 hours later.

In addition, there are fire hazard concerns. Accumulations of methanol vapors in confined spaces may explode if ignited, and containers filled with methanol may rupture violently if exposed to fire or excessive heat for a prolonged duration.

Below are some guidelines to consider specifically as it pertains to the safe handling of methanol:

Safe Handling Guidelines:

- Avoid prolonged or repeated breathing of methanol vapors.
- Methanol should always be kept within closed systems or approved containers and stored in a secure space.
- Wear proper attire when handling methanol, including appropriate footwear, face shields or safety spectacles, gloves and respiratory protection.
- Do not smoke or permit smoking anywhere near the area where methanol is stored. Do not use torches or any ignition source near the area where methanol is stored, as even small amounts of lingering vapors in the area or in an apparently empty storage container can ignite and result in a dangerous blast and/or fire.
- If a methanol spill occurs, stop or reduce discharge of material if this can be done without risk. Isolate the spill or leak area immediately for at least 330 to 660 feet in all directions. Eliminate all sources of ignition, and stay upwind. Do not touch or walk through the spilled material.
- Prevent methanol from entering into waterways, sewers, basements or confined areas. Do NOT pour methanol down the drain. Methanol is a hazardous material and must be disposed of properly. Check with local environmental officials for instructions on how to safely dispose of methanol in your community.
- A vapor suppressing foam may be used to reduce vapors. For small spills (up to 55-gallon drum) absorb with earth, sand or other non-combustible material and transfer to containers for later disposal. For large spills, dike far ahead of liquid spill for later disposal, and follow local emergency protocol for handling.
- Spills into large natural bodies of water, such as rivers and oceans, cannot be contained. For releases into soil, surface water or groundwater, methanol has a half-life of just one to seven days, and given its high rate of biodegradation, methanol spills are not likely to persist. Again, methanol must be disposed of properly, do NOT attempt to dump methanol on the ground or in any body of water. Methanol is used extensively in the nation's wastewater treatment facilities to reverse the damaging effects of nitrate buildup in sensitive aquifers and waterways by accelerating biodegradation. As a flammable and toxic chemical, caution must be exercised to avoid contact with methanol.

First Aid Recommendations:

- In case of methanol contact with skin, remove contaminated clothing, wash with soap and water for 15 minutes, and seek medical attention if irritation occurs.
- If methanol comes in direct contact with eyes, immediately flush eyes with copious amounts of tepid water for at least 15 minutes. The patient should be taken to a health care facility and referral to an ophthalmologist considered.
- In case of inhalation of methanol vapors, remove individual to fresh air. Asphyxiation from vapors may require artificial respiration.
- Ingestion of methanol is life threatening. Onset of symptoms may be delayed for 18 to 24 hours after ingestion. Due to the risks of aspiration into the lungs, do NOT induce vomiting. The decision to induce vomiting should be left to a medical professional attending the victim. Transport immediately to a health care facility where standard methanol ingestion treatment can be administered. Immediate medical attention is critical!

H. A Final Word: Should You Make Your Own Biodiesel?

You certainly can make your own biodiesel – many people have for years – and now some companies offer “kits” or at-home production units to make biodiesel. The question is, should you? Following are a few points to consider:

- *In no way* should you be making your own biodiesel unless you receive proper training and instruction from a *professional* on how to store, transport and use biodiesel, methanol and other components of biodiesel (e.g., lye).
- Be wary of claims from Internet sites and Web blogs about how “easy” it is to make your own biodiesel, and be especially aware of Web “recipes” for biodiesel. *Moreover, some Internet companies will sell biodiesel kits, but do not offer any information on obtaining feedstock supplies of vegetable oils, methanol and lye and how to handle them safely.* Before purchasing a biodiesel kit, make sure you have secured access to the necessary feedstock chemicals from a reputable dealer.
- Only purchase materials from reputable suppliers. Methanol is sold in quantities ranging from 55-gallon drums to deliveries of thousands of gallons in trucks, railcars and barges. Many distributors will not ship methanol to a residential or farm address, and some require minimum orders of \$300 or more. The purchase price for methanol will vary considerably depending on the delivered quantity, location and frequency of delivery. For more information on how to purchase methanol, please contact the Methanol Institute. You may visit MI’s web site at www.methanol.org, where you will find a simple on-line Methanol Source Request form on the “Biodiesel” page. Simply complete and submit the on-line form, and MI will share your request with a number of methanol producers and distributors.
- Can you assure that the quality of the biodiesel meets specifications? Many biodiesel producers have in-house labs or take other measures to ensure that the quality of the biodiesel they produce meets ASTM standards for optimal performance of diesel engines and vehicles.
- How will you store the biodiesel? Storage is another quality-related issue as biodiesel should be stored for six months or less to ensure it does not become contaminated.
- How much biodiesel will you actually use? If you use a small amount of biodiesel, it may be more cost-effective to simply purchase your biodiesel from a reputable producer or retail distributor. To find a biodiesel source in your area, contact the National Biodiesel Board.
- Many people want to make their own biodiesel to partake in fiscal incentives at the state and federal levels; however, these incentives are generally geared toward larger biodiesel producers and petroleum refiners and distributors that blend biodiesel.
- At what percentage will you use the biodiesel? Remember, most engine and vehicle manufacturers warrant their vehicles for use of up to B5. The use of high-level blends (B20+) and pure biodiesel, B100, should probably be avoided.

I. Internet Sources to Consult for More Information

Following is a list of sources to consult for more information on biodiesel and methanol, but note that this list is not exhaustive:

1. Alliance of Automobile Manufacturers, et al., World Wide Fuel Charter (proposed revision August 2005), <http://www.autoalliance.org>.
2. Australian Biodiesel Association (BAA), <http://www.biodiesel.org.au/>.
3. Biodiesel Association of Canada, <http://www.biodiesel-canada.org/>.
4. Centre for Jatropha Promotion (India), <http://www.jatrophaworld.org/>.
5. Engine Manufacturers Association (EMA), <http://www.enginemanufacturers.org/info/>.
6. European Biodiesel Board, <http://www.ebb-eu.org/>.
7. European Commission, New & Renewable Energies, *Biofuels for Transport*, http://europa.eu.int/comm/energy/res/legislation/biofuels_en.htm.
8. European Commission, Agriculture, *An EU Strategy for Biofuels* http://europa.eu.int/comm/agriculture/biomass/biofuel/index_en.htm.
9. The European Federation of Vegetable Oils Producers (FEDIOL), <http://www.fediol.be/>.
10. 2005 European Barometer of Renewable Energies, 5th Report, Euroserv'er, <http://www.energies-renouvelables.org/>.
11. Malaysian Palm Oil Board (MPOB), <http://www.mpob.gov.my/>.
12. Methanex Corporation, Technical Information & Safe Handling Guide for Methanol (Oct. 2002) *available at* http://biodiesel.org/pdf_files/Methanol_Handling_Guide.pdf.
13. Methanol Institute, Biodiesel & Methanol: Working Together *available at* www.methanol.org (*last visited* Feb. 27, 2006).
14. Methanol Institute, Methanol Emergency Response *available at* www.methanol.org (*last visited* Feb. 27, 2006).
15. Methanol Institute, Methanol Health Effects *available at* www.methanol.org (*last visited* Feb. 27, 2006).
16. National Biodiesel Board, <http://www.biodiesel.org>.
17. National Biodiesel Accreditation Program, BQ-9000, <http://www.bq-9000.org/>.
18. National Renewable Energy Laboratory, Biodiesel Publications, http://www.nrel.gov/vehiclesandfuels/nbpf/pubs_biodiesel.html.

19. Department of Alternative Energy Development and Efficiency (DEDE), http://www.dede.go.th/dede/default_e.asp
20. U.S. Department of Energy, Energy Efficiency & Renewable Energy, Alternative Fuels Data Center, *FAQs about Alternative Fuels available at* http://www.eere.energy.gov/afdc/progs/display_faqs.cgi?afdc/0 (last visited Feb. 27, 2006).
21. U.S. Department of Agriculture, <http://www.usda.gov>.
22. U.S. Environmental Protection Agency, Renewable Fuels Program, <http://www.epa.gov/otaq/renewablefuels/index.htm>.
23. Ministry of Non-conventional Energy Sources (MNES) (India), <http://www.mnes.nic.in/>.
24. Planning Commission (India), <http://planningcommission.nic.in/>.

J. Biodiesel Unit Conversions

The chart below provides a simple way to convert biodiesel from different units. In the U.S., biodiesel is typically expressed in gallons, while in Europe and other parts of the world, biodiesel is expressed in tons and/or cubic meters.

Table 8. Biodiesel Unit Conversions

| Metric Tons | m ³ | US Liquid Gallons (in millions) |
|-------------|----------------|------------------------------------|
| 1,000 | 1,136 | 0.30 |
| 880 | 1,000 | 0.26 |
| 3,333 | 3,788 | 1.00 |

Source: IFQC Biofuels, 2006.

For a biodiesel with a density of 880 kg/m³ (the mid-point of the European EN14214 specification) the above table illustrates equivalent quantities of biodiesel expressed in terms of both mass and volume.

K. More on the Methanol Institute

The Methanol Institute (MI) and its research arm, the Methanol Foundation, represent the global methanol industry. Our mission is to expand markets for the use of methanol as a chemical commodity building block, a hydrogen carrier for fuel cell applications, and an alternative fuel. MI was formed in 1989, during the height of the Clean Air Act debate, and worked to help create the highly successful reformulated gasoline program.

Today, methanol is one of the world's most widely distributed chemical commodities. As a basic building block for hundreds of chemical products, methanol is being used safely and effectively in everything from plastics and paints, to construction materials and windshield washer fluid.

The emergence of fuel cell technologies has the potential to create vast new markets for methanol as the hydrogen carrier of choice. Methanol fuel cell technologies can be used to power zero and near-zero emissions cars, buses and trucks. In the growing market for distributed power, stationary fuel cell systems for residential and commercial applications can

also be fueled with methanol, particularly in rural locations that do not have access to natural gas lines. The earliest consumer markets for methanol fuel cell technology will power everything from laptop computers and cellular phones, to lawnmowers and portable power generators.

MI is encouraging the development of several emerging markets for methanol. Wastewater treatment plants are using methanol to reduce nitrates that can literally kill small and large water bodies. Methanol is also considered a “superior” fuel for electric power turbines, providing an alternative to natural gas and distillate fuels that significantly reduces nitrogen oxide emissions.

Promoting the development of innovative technologies to produce methanol from renewable resources is a central focus of MI. Landfill methanol gas is being purified into a synthesis gas for the production of methanol at pilot plants in New Jersey and New York, and full commercial demonstrations in Ohio and elsewhere.

MI directs international efforts relating to methanol product stewardship and regulatory affairs. For example, MI formed a testing team to respond to the U.S. EPA’s High Production Volume Chemical Testing Challenge Program, completing a rigorous analysis of the health and environmental research available on methanol. This work will form the basis for a review of methanol by the international community.

Read more about the Methanol Institute at <http://www.methanol.org/> or contact the Methanol Institute at +1.703.248.3636.

L. More on the International Fuel Quality Center

The *International Fuel Quality Center (IFQC)* aims to improve communications among world refining, automotive, and technology supplier stakeholders, as well as governments to help advance their respective organizational goals while providing for a cleaner environment. We are proud to assist more than 700+ industry executives from more than 100 leading organizations to better understand global fuel quality developments and their impact on the global refining technology and automotive markets and vice-versa, as well as assist with their business developments. With that mission in mind, *IFQC*:

1. Provides quality information and concise analysis with an emphasis on automotive fuel quality data, global refining issues and timely industry, legislative, and regulatory analysis.
2. Recognizes that all future environmental and corporate decisions must acknowledge the vehicle and fuel as an integrated system.
3. Recognizes industry and government for their accomplishments and leadership.

Importantly, IFQC does not take positions and is the only organization of its kind that is non-biased and represents all stakeholders.

Similar to IFQC, our aim with the IFQC Biofuels Center is to highlight and gather all available information on biofuels globally for our members to enable them to make sound decisions based on industrywide information, experience and analysis. Our objective is to bring into one Center all relevant information from the global biofuels market for stakeholders and decisionmakers around the globe. And, as with IFQC, we do not advocate any position.

Read more about IFQC at <http://www.ifqc.org> and the IFQC Biofuels Center at <http://www.ifqcbiofuels.org> or contact Tammy Klein, Director, Global Biofuels & Americas at +1.701.323.0417.